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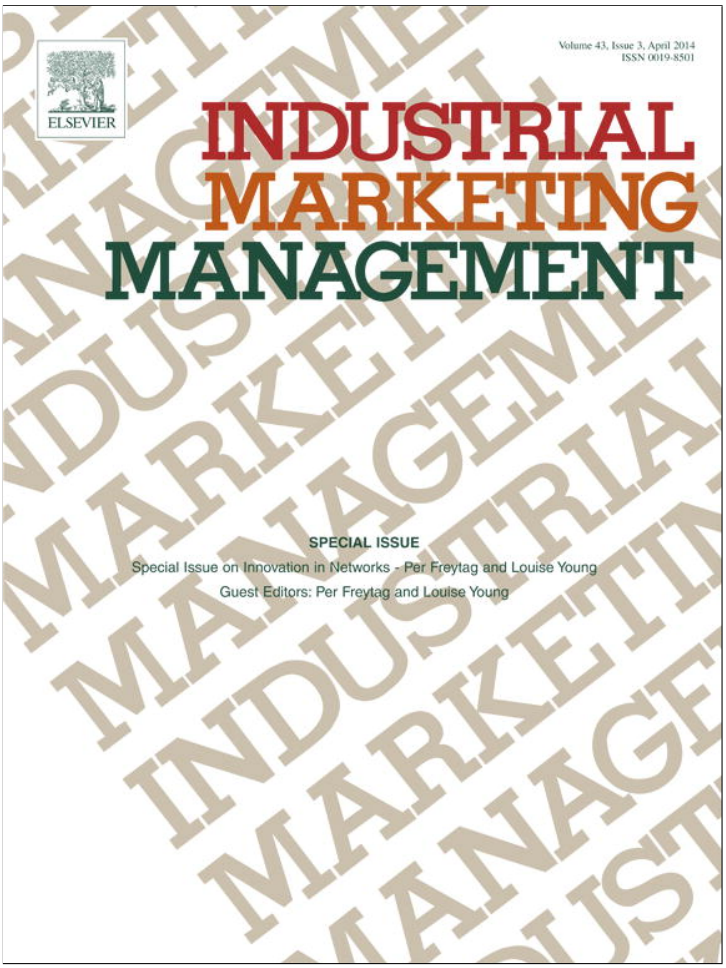

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Knowledge sharing in heterogeneous teams through collaboration and cooperation: Exemplified through Public–Private-Innovation partnerships

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ABSTRACT

According to literature on teams and group learning it is important for heterogeneous teams to share knowledge, through the use of different forms of interaction. However, little is known about how different forms of interaction influence knowledge sharing and secure progress during innovation processes. In order to achieve an increased understanding, literature concerning teams and group learning are integrated within a case study of Public–Private-Innovation partnerships (PPI). Specifically, the distinction between different forms of interaction, such as collaboration and cooperation is used to clarify how knowledge sharing and progress are influenced during innovation processes. Three PPI projects have been chosen due to the particularly challenging nature of their composition; consisting of heterogeneous members from both the public and private sectors with dissimilar logics. Overall, our findings point out that 1) those heterogeneous teams that are able to continually integrate their team members' heterogeneous knowledge through a balanced use of collaborative and cooperative interaction forms seem to secure progress during the innovation process, and that 2) those heterogeneous teams that are able to continually re-establish a shared knowledge base, when it has been challenged by a critical incident, seem able to achieve progress during innovation processes.

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1. Introduction

Firms increasingly recognise the importance of developing and managing relationships with external partners in the value producing system (Wilkinson & Young, 2002). The literature concerned with how heterogeneous teams perform, indicates the particular importance of sharing knowledge and creating a shared knowledge base, if the innovation process taking place between heterogeneous team members is to be efficient (Marin-Garcia & Zarate-Martinez, 2007; Sapsed, Bessant, Partington, Tranfield, & Young, 2002). However, the literature seems unconcerned with which forms of interaction heterogeneous teams can use to share and integrate knowledge to enable innovation processes. Group learning theory distinguishes between cooperation and collaboration which are two different forms of interaction. Where collaboration refers to strong linkages and high level of trust and knowledge sharing between team members, cooperation refers to transferring of knowledge among team members (Keast, Brown, & Mandell, 2007; Roschelle & Teasley, 1995). The collaborative form of interaction is necessary if heterogeneous teams are to share knowledge, and using the cooperative form of interaction is necessary if heterogeneous teams are to secure progress during innovation processes. The aim of this paper is to achieve a better understanding of how very heterogeneous teams, share knowledge and secure progress during the innovation process through the use of these different interaction forms.

Very heterogeneous teams are considered in the context of Public–Private-Innovation partnerships (PPI). This refers to a setting in which public and private players work together to develop innovative solutions targeting the public sector (Dittmer, Christiansen, & Kierkegaard, 2008, p. 241). The players are considered to be development partners aiming to innovate through a continuous transfer of ideas and knowledge between the players involved (Weihe et al., 2011). This context has been selected because on the one hand it is an increasingly widespread phenomenon and on the other hand it represents a situation where there is profound heterogeneity within the teams and therefore challenges in how knowledge is shared and how progress during innovation processes is made noticeable. PPIs are considered to be heterogeneous as the team consists of public and private actors with very different values and objectives (Currie, Humphreys, Ucbasaran, & McManus, 2008; Drejer & Jørgensen, 2005; Hartley, 2005; Schmidt, 2008; Van der Wal, de Graaf, & Lasthuisen, 2008). These sectorial differences are demanding to manage within PPI teams because the heterogeneous actors have to define problems and explore solutions jointly, which requires knowledge sharing and integration,

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and requires the ability to secure progress. However, what is still lacking in the sparse PPI literature is knowledge about how these challenges can be managed in order for knowledge sharing to take place and secure progress.

The research question is: *How do heterogeneous teams share knowledge and secure progress during innovation processes through the use of the different interactions forms collaboration and cooperation?*

When investigating the above question, a process approach to innovation is emphasised, focusing on how heterogeneous teams share knowledge and make progress. To capture this we focus on meetings where critical incidents (potentially) take place. During critical incidents (which we define as interactions where important changes are occurring and are being addressed) knowledge sharing and progress are particularly challenging. This leads to a focus not on the whole innovation process, but on those parts where knowhow accumulation and learning that address change are taking place (Nielsen & Lundvall, 2003; Rothwell, 1994).

The paper is structured as follows. First, the theoretical section is presented, which consists of reviews of the team literature and group learning literature. Here, the question of how heterogeneous teams can handle the innovation process by continuously creating a shared knowledge base through the use of collaborative or cooperative forms of interaction is discussed. Then the methodology is presented, and three PPI cases in the hospital sector are introduced. Afterwards, we present our results and discuss their implications. Finally, we conclude with our findings and offer implications for theory and management.

2. Theoretical literature review

2.1. Sharing knowledge in heterogeneous teams

Teams are characterised as social entities composed of members who must integrate, synthesise and share information and expertise during a process in order to achieve shared common goals, and to conceptualise, develop and commercialise innovative products (Salas, Cooke, & Rosen, 2008, p. 541; Edmondson & Nembhard, 2009, p. 124). In heterogeneous teams, the extent to which differences between the team members need to be integrated in order to share knowledge is often high. Integration of differences is the team members' ability to incorporate the other team members' knowledge in order to create a shared knowledge base during innovation processes (Sapsed et al., 2002).

Heterogeneity within teams is argued to be a challenge because of potential tensions and conflicts, but diversity also heightens team performance because too much comfort and familiarity reduce productivity (Edmondson & Nembhard, 2009, p. 124). Members of heterogeneous teams bring in not only diverse knowledge and information, but also different vocabularies and cognitive patterns (Drach-Zahavy & Somech, 2001, p. 114).

Knowledge sharing within heterogeneous teams is important in order to manage the heterogeneity and to produce progress during innovation processes. Knowledge sharing is necessary to integrate the different disciplines, ideas, knowledge and information possessed by the different team members and bring about (more) frequent communication (Cooke, Salas, Cannon-Bowers, & Stout, 2000; Edmondson & Nembhard, 2009; Ratcheva, 2009, p. 210). This kind of knowledge sharing is important because when very different knowledge bases among team members are non-integrated, the innovation process is slowed and complicated (Sapsed et al., 2002, p. 81). On the other hand, when the individual team members' knowledge tends to be similar or overlaps, team working is more efficient because a tacit understanding is developed and shared and there is less need for explanations and demonstration (Marin-Garcia & Zarate-Martinez, 2007, p. 283; Sapsed et al., 2002, p. 81). Tacit knowledge requires team interaction/sharing (Sapsed et al., 2002, p. 72) because unlike explicit knowledge, tacit knowledge cannot be transferred across time and space independently of the team members' interactions. Instead, sharing tacit knowledge requires close interaction and establishment of a shared understanding among the team members (Lam, 2000, p. 490).

Tacit knowledge sharing occurs through the sharing of team members' mental models. This involves team members assessing mutual expectations that allow them to coordinate and make predictions about the behaviour and needs of their teammates (Cooke et al., 2000, p. 152). The establishment of a shared knowledge base both facilitates a team's achievement of a collective understanding of a specific situation and their coordinated change as the situation itself changes (Cooke et al., 2000). When this type of knowledge sharing succeeds, it provides a collective understanding and a shared knowledge base for team members to draw upon when task episodes arise (Cooke et al., 2000, p. 153).

However, there is also a point at which too much overlapping of knowledge can reduce team performance (Cooke et al., 2000, p. 156). In its extreme form, shared knowledge can be considered as 'groupthink' and this makes it more difficult to make decisions due to pressures within the group to maintain conformity (Cooke et al., 2000, p. 156). Thus, the literature suggests that instead, team members should possess different but complementary knowledge in addition to shared knowledge (Cooke et al., 2000, p. 156).

To enhance team performance during the innovation process, heterogeneity needs to be dealt with through interaction, but without dissolving the distinction between the heterogeneous knowledge bases among the team members. This means that the ability to perform as a team during the innovation process depends on the team members' ability to hold both a common shared knowledge base that cuts across team members *and* different complementary knowledge bases attached to the tacit knowledge (mental-models) held by the individual. To characterise team performance in the innovation process the team literature makes a distinction between individual taskwork and teamwork (LePine, Hanson, Borman, & Motowidlo, 2000; Lim & Klein, 2006; Salas et al., 2008). *Taskwork* is defined as the components of a single team member's performance that do not require interdependent interaction with other team members, whereas *teamwork* is defined as the interdependent components of performance which require interaction and coordination of the performance of multiple team members (Salas et al., 2008, p. 541). However, the team literature does not clarify how to combine these different ways of performing during an innovation process to secure progress and continuous knowledge sharing. In order to explain how such combinations influence knowledge sharing in heterogeneous teams, the insights of learning theory are needed because it focuses on different interaction forms within groups.

2.2. Combining the collaborative and cooperative forms of interaction

The distinction between the processes of teamwork and taskwork is very similar to the distinction between cooperation and collaboration. Cooperation and collaboration can be viewed as two different forms of interaction. Thus, collaboration and teamwork are similar because they are both characterised by strong linkages and interdependency between members of a group or a team. Researchers in innovation have been particularly concerned with collaborative learning, since it explains how interacting with others in groups makes the individual master new approaches (Bruffee, 1995, p. 14; Dillenbourg, Baker, Blaye, & O'Malley, 1996, p.1; Dois & Palmonari, 1984, p. 11). In contrast, both cooperation and taskwork are characterised by group members or team members being autonomous and independent during the innovation process.

The distinctions are summarised in Table 1 in terms of cooperation and collaboration and taskwork and teamwork. In practice they do not necessarily occur solely in their pure forms (Bruffee, 1995) but rather there is a continuum of the degree of interaction.

Cooperation is characterised by the division of labour and sharing or transferring of information among actors in a group, where each one is

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Table 1
Key dimensions of cooperation and collaboration.

Central dimensions	Taskwork and cooperation	Teamwork and collaboration
Distribution of tasks and responsibilities	Separate assignments/distribution of tasks and delineation of responsibilities	Joint problem solving/community and common tasks
Type of task	Defined tasks	More open tasks
Linkages between the team members (degree of interactions, dialogue, etc.)	Weak linkages	Strong linkages
Context	Team members work in different contexts	Team members work in a common context

regarded as autonomous and independent from the others (Dillenbourg et al., 1996, p. 2; Keast et al., 2007, p. 25; Roschelle & Teasley, 1995, p. 70). Cooperation is concerned with the coordination of tasks, which also implies a clear positioning of responsibilities among the actors.

At the other end of the continuum, *collaboration* is characterised by strong linkages depending on a high level of trust and dialogue among several actors who are working together in order to resolve a task and achieve a shared goal; but it also contains a high level of risk compared with cooperation (Dillenbourg et al., 1996, p. 2; Keast et al., 2007, p. 19). Unlike the case in cooperative relationships, the actors have a holistic perspective because they see themselves as interdependent and recognise that they need to work together across boundaries and between sectors or organisations rather than separately (Keast et al., 2007, p. 25). Therefore, a collaborative process requires a high intensity of linkages between a diverse set of actors within a team, in order to develop shared common goals and a better understanding of the project as a whole. This is not an easy task, since collaboration in the face of differences is particularly difficult (Edmondson & Nembhard, 2009, p. 124).

Elements of both cooperation and collaboration are likely to be present. For example collaboration may involve some spontaneous division of labour (Dillenbourg et al., 1996). Changing circumstances and requirements in a relationship between several actors means that a changed mix of cooperation and collaboration may arise. Keast et al. (2007) argue that adjustment and responding to changing situations in a relationship entail "ramping-up" to collaboration or "scaling down" to cooperation and that many hybrid-iterations can be developed (Keast et al., 2007, p. 26). The combination of cooperation and collaboration is identified as the actors' ability to be able to know what to use at what time, depending on the nature of the issues to be dealt with (Keast et al., 2007).

By distinguishing between cooperation and collaboration it is possible to identify how the mixing of the two forms of interaction can be used to manage the challenges of sharing knowledge and ensuring progress during innovation processes. Sharing tacit knowledge is especially important if a shared knowledge base is going to be achieved. The sharing of tacit knowledge is related to collaboration because this requires close interaction in order for the heterogeneous team members to achieve an understanding of each other's vocabularies, views, etc. On the other hand, the sharing of explicit knowledge is more related to cooperation because this type of interaction does not require close interaction between team members in order to share knowledge. However, sharing of explicit knowledge related to the team members' functional professions is important in order to benefit from the team members' specific knowhow. The following case explores these two forms of interaction and considers how it is possible to combine them, so as to manage the challenge of creating a shared knowledge base in a heterogeneous team that has innovation among its objectives.

3. Methodology: case study and participant observation

Three PPI projects have been chosen because of the particularly challenging nature of their composition; they consist of heterogeneous members from both the public and private sectors with dissimilar logics. Organisations in the public sector are concerned with the general community and are collectively oriented (Bozeman & Bretschneider, 1994; Perry & Rainey, 1988; Weintraub & Krishan, 1997). Furthermore governments aim to foster innovations in order to achieve regional development and foster business opportunities to create economic growth (Lundberg & Andresen, 2012, p. 430). Organisations from the private sector are concerned with more individual matters focusing on the interest and aims of single firms (Perry & Rainey, 1988, p. 193). As a result, when public and private players work together in PPI, diversity in viewpoints and goals are in play.

The three projects' processes are explored to ascertain how, despite team members' different logics, values and aims, are managed. The three PPI cases were selected based on three criteria: 1) The PPIs could be followed from their inception and during their innovation processes. 2) The PPIs should, from their inception, include public and private members to ensure that diverse teams were being investigated. 3) The team members of PPIs are purely developmental partners during the innovation process.[3]

A qualitative research strategy and case study methodology was chosen (Maaløe, 1996; Yin, 2003). This approach is recommended when issues are complex and in cases where alternating between the empirical field and different theoretical frameworks can be useful for generating additional insights (Orton, 1997; Yin, 2003). Specifically, empirical data were gathered based on participant observation (Dewalt & Dewalt, 2002). Participant observation made it possible to gather data that indicate how central parts of the innovation process unfold over time. A unique timeline could thus be constructed for each of the three cases. Throughout the observations, we recorded detailed descriptions of meetings and incidents that constituted (potential) change in knowledge sharing activities and forms of interaction. This kind of process study attempts to identify situations that (potentially) create a particular twist or turn in a case, and to capture the flow of incidents in a narrative that explains the development in a case over time (Poole, Van de Ven, Dooley, & Holmes, 2000).

To guide our participant observations we, in part, used a critical incident technique (Burns, Williams, & Maxham, 2000; Roos, 2002). This technique can be described as an observed incident involving human activity or behaviour, which contributes to the success or failure of some activity or phenomenon (Burns et al., 2000). The critical incident technique has enabled us to identify 1) occurrences and recurrences of knowledge sharing during the innovation process, and the related challenges between public and private team members, 2) how PPI

[3] To clarify what kind of a partnership PPI actually is, it will be distinguished from Public Private Partnerships and Triple Helix Partnerships: *Triple Helix Partnerships* typically focus on university–industry–government relations (Cantù, 2010, p. 887; Etzkowitz & Leydesdorff, 2000, p. 109). PPI distinguishes itself from the Triple Helix Model since it does not necessarily include universities. Instead PPIs often include public municipal and regional organisations as representing the public actors. When it comes to Triple Helix Partnerships that are based on generating innovation, partnerships in the OECD countries have long been based on private firms and public research institutions in relation to technology and product development (Lundvall, 2002, p. 145). *Public Private Partnerships* (PPPs) are contractual partnerships between public and private actors, and governments have had partnerships with the private sector for a long time (Greve & Hodge, 2005, p. 3). PPPs are partnerships that are characterised by a typical contractual buyer–supplier relationship without a particular focus on innovation. PPPs typically extend over a few decades, and the main incentive for establishing a partnership is risk-sharing (Greve & Hodge, 2005, p. 4; Klijn & Teisman, 2003, p. 137; Roehrich & Caldwell, 2012, p. 13). Besides risk sharing, there is also the prospect that the partnership may result in a new product or service targeted at the public sector, which could not have been attained by the public or private sector alone (Greve & Hodge, 2005, p. 4). This latter aspect of PPP is much in line with the prospects of PPI (Weihe et al., 2010, p. 11).

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members have reacted during the critical incidents, 3) actions taken by PPI members during the critical incidents and 4) changes (if any) in how the PPI members have acted afterwards. This framework made it possible to identify which forms of interaction seem to secure knowledge sharing and progress during the innovation process. Ethnographic observation took the form of one or two researchers attending every meeting of teams making it possible to take part in their activities, interactions and on a continuing basis for 1½ years.

To conduct the empirical analysis a hands-on grid analysis (Gordon, 1969; Stephens & Gammack, 1994; Basit, 2003) was developed. Grid analysis is used for data condensation or data distillation (Basit, 2003) and allows the researchers to categorise empirical data based on predetermined themes inspired by theory (e.g. a provisional start list recommended by Miles & Huberman, 1994) as well as exploring for new theoretical themes grounded in the empirical data. The themes in the grid analysis were extracted from the PPI literature, team literature and group learning literature concerning tensions and how knowledge is shared through different forms of interaction. This analysis identified an important point: sharing and integrating knowledge through the use of different interaction forms is a *continuous* negotiation process.

3.1. Three PPI cases from the hospital sector

In the following, three cases of heterogeneous teams containing public and private members are presented. The project, which ran from 1 January 2010 until 31 December 2012, focused on central sterile departments in hospitals. Each team is responsible for a subproject that was part of an overall project concerned with a fully automatic central sterile department and procedure pack. The aim was to develop and produce relevant tools and design elements, including procedures for design and innovative procedures for the health sector — specifically, automating central sterile departments with the focus on future engineering methods and techniques. The PPI project was expected to result in increased efficiency and less attrition of personnel. It also sought to improve bacterial control in the process of re-handling instruments.

In the beginning of the project, all the members participated in workshops, visited central sterile departments and attended a consultant presentation focusing on the processes in central sterile departments. These collective activities resulted in the identification of different themes for subprojects. At a joint meeting in November 2010, the project members chose which subproject they wanted to be part of. An overall project management team controlled and supported the subprojects through two to three joint meetings held yearly during the project period. At these joint meetings, exchange of experiences took place between the teams. The three subprojects are, for the sake of simplicity, referred to as *Case 1*, *Case 2* and *Case 3*. An overview and differentiation of the cases are presented in Table 2.

4. Case study analysis

The following analysis identifies how PPIs use different forms of interaction to share knowledge, create a shared knowledge base and secure progress during innovation processes. To get an overview of the innovation process in each of the three cases, a timeline, including different types of meetings and critical incidents, is presented — facilitating the understanding of sharing knowledge as an emerging process.

Two types of meetings were held, both were typically one-day-meetings: 1) joint meetings where all the teams were gathered together and, 2) sub-project meetings where only members of a single team participated. The joint meetings were facilitated by the overall project management group, whereas members of the sub-projects organised the sub-project meetings. The overall goal of the joint meetings was to create knowledge sharing between the teams and to facilitate feedback from other teams on the latest sub-project results, and to inspire and create progress in the teams. The overall goal of the sub-project meetings was for the team members to engage in the process of developing specific, innovative solutions for central sterile departments.

For each of the cases critical incidents, which created some change in knowledge sharing activities during the innovation process, are identified. Furthermore, each timeline includes an illustration of the evolution and relative amounts of the collaborative and cooperative forms of interaction. After each timeline, a further description explains the flow of meetings and incidents as they developed in the case over the 1½ year period.

4.1. Case 1

In Case 1, a fairly balanced combination of cooperation and collaboration was initially established in order to share knowledge, create a shared knowledge base and secure progress during the innovation process. The team's ability to create a shared knowledge base by balancing collaborative and cooperative interaction forms was however, severely challenged by three critical incidents, as indicated in Fig. 1. (See Figs. 2 and 3.)

Table 2
Overview of the three PPI cases.

Aim	Types of members
Case 1 aimed to develop an autoclavable case cart for central sterile departments in hospitals. The public and private members were part of the subproject for an equal length of time. The result of the process has been the development of a prototype trolley that was tested in one of the private members' firm and at a Danish hospital.	*Case 1* consists of two public and four private members: Public members: 1 manager of a central sterile department. 1 charge nurse in a central sterile department in another hospital. Private members: 1 self-employed consultant with a professional background in central sterile departments (project leader). 1 owner of a private firm in the aluminium industry. 1 business developer from an aluminium knowledge network. 1 Head of Development in a private firm within the industrial machine-wash industry.
Case 2 aimed to improve the overall processes in central sterile departments in hospitals. The public and private members were part of the subproject for an equal length of time. The result of the process has been the development of a report that shows scenarios of the overall flow of surgical instruments in a central sterile department.	*Case 2* consists of four public members and two private members: Public members: 1 charge nurse in a central sterile department. 1 nurse in the same central sterile department. 1 engineer and assistant professor from a university (project leader). 1 Ph.D. student from the same university. Private members: 1 owner of a private IT firm specialising in IT systems. 1 consultant from a technological institute that develops, applies and distributes research- and technologically-based knowledge for the Danish and international business sectors.
Case 3 aimed to develop an automatic system for identification and registration of surgical instruments. The public and private members were part of the subproject for an equal length of time. The result of the process nearly caused the project to shut down.	*Case 3* consists of two public and four private members: Public members: 1 functional manager of a central sterile department (project leader). 1 charge nurse in a central sterile department in another hospital. Private members: 1 Head of Development in a private firm within the industrial machine-wash industry. 1 owner of a private IT firm. 1 self-employed consultant with a professional background in central sterile departments. 1 technical manager from a firm that develops industrial solutions especially with a focus on robots.

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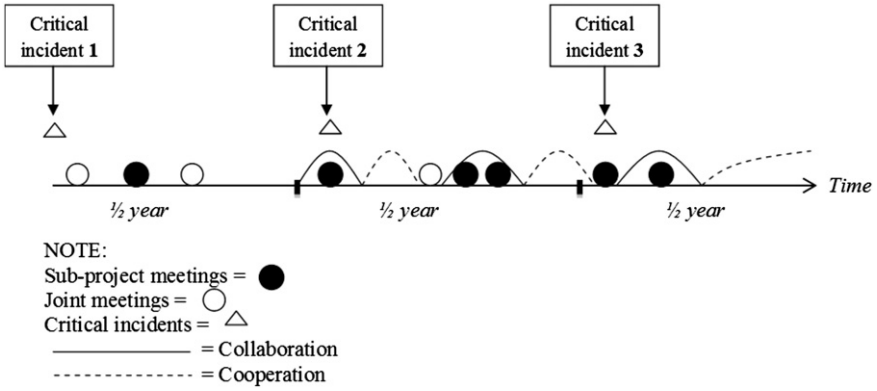

Fig. 1. Meeting activities and critical incidents for Case 1.

The first critical incident (1) occurred before the team's first meeting. Discussions between two members from the private sector created a disturbance at the beginning of the project because these two members perceived each other as competitors. At the first this led to difficulties in sharing knowledge and reaching a shared knowledge base. The members from the private sector perceived the risk in sharing their technical knowledge as being too high, which led to stagnation in the innovation process in the first six months and no particular dominant form of interaction established among the team members during this period.

At the following meeting, which was organised after several months with no activity within the team, a second critical incident (2) occurred. One of the private sector members voluntarily withdrew from the PPI project and did not participate in the meeting thereby resolving the conflict. However, this created uncertainty as to whether the project would continue or not. The critical incident was resolved by the project leader, who took an authoritative position and stated that the team had to decide whether to continue or not. This ultimatum seemed to create the motivation to continue and to engage in close interaction. A willingness to share knowledge through teamwork arose. Through the ensuing team working process, collaborative interaction took place among the team members. The collaborative form of interaction between all members manifested itself during a number of hours of close dialogue concerned with the possibilities of constructing a new kind of autoclavable case cart (trolley). There was disagreement about the measures and technological design of the case cart. Here, explicit knowledge about specific technical possibilities and proposals from the private members were at variance with the public members' more practical concerns; they argued that a new type of case cart should improve work processes at a central sterile department. Thus an integration of explicit knowledge helped to form a shared knowledge base about the design and functions of the case cart. Furthermore, tacit knowledge was exchanged with a common understanding of work processes and a common language in relation to that emerging. A first version of a shared knowledge base thus seems to have been created, from the resolution of this critical incident.

By the end of the second meeting the level of unpredictability within the team was reduced. The process that followed was characterised by cooperation, as the team members agreed to solve defined tasks. The private members were going to construct parts of the case cart prototype which was going to be tested at the next meeting, while the public members were going to collect surgical instruments which would be included in the test.

After this period of cooperation, a collaborative form of interaction arose once more. The next few of meetings took place during a two-day-seminar at the firm of one of the private members, where the aim was to test the first prototype of a case cart. The meetings were characterised by collaboration among the team members and the relationship between the team members seemed to develop further. During testing, the collaborative form of interaction manifested itself in more informal contact between the public and private members. Tacit knowledge sharing appeared to be easier because the team members developed a collective understanding of the aim with the case cart.

After testing the prototype, the subsequent joint meeting was characterised by a third critical incident (3). Other team members (from another case) questioned the need and demand for the case cart in Danish hospitals. Other issues arose, including EU procurement rules, and a requirement to publish results from the project. This led to one of the private members in Case 1 reconsidering his engagement in the project. The private member was not keen on publishing the

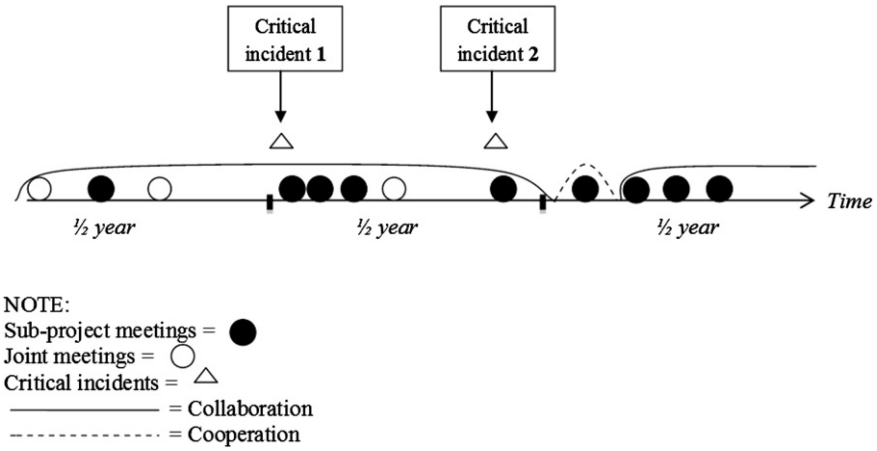

Fig. 2. Meeting activities and critical incidents for Case 2.

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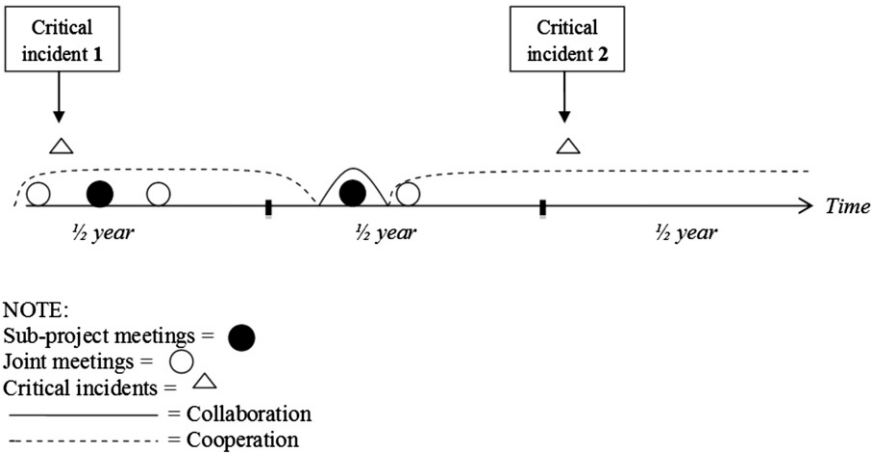

Fig. 3. Meeting activities and critical incidents for Case 3.

case cart results, and furthermore he was also worried about the business potential. This affected the private member's engagement in the project and resulted in a short interruption in the teams' dialogue and interaction.

At the beginning of the next meeting, the team members were hesitant to engage in close interaction. However, the project leader took an authoritative position again and suggested that they should focus on creating a business case and testing the case cart in a Danish hospital. All the team members participated in collaborative interaction in the form of close dialogue and a renegotiation of a shared knowledge base was displayed at the meeting as the members collectively shared their knowledge about the possibilities for undertaking a new test. At the end of the meeting, the project leader moved the team from the spontaneous collaborative interaction to cooperation, with the rest of the meeting characterised by the distribution of responsibilities. The specific tasks were to find and contact a hospital where the case cart could be tested (public members' task) and make small adjustments to the case cart (private members' task). As a result of the third critical incident, the level of dependency among the team members rose. The private members were especially dependent on the public members' explicit knowledge about hospitals where the prototype could be tested.

4.2. Case 2

Case 2 is dominated by the use of the collaborative interaction form. Most of the meetings held were characterised by the public and private members being highly collaborative as they spent time solving tasks together in order to get to know each other's work context and professional skills. In this case, only a few critical incidents occurred during the innovation process and the critical incidents that did occur were minor and handled easily. The model displays the innovation process in Case 2.

Distribution of tasks and responsibilities is not apparent during the innovation process of Case 2. Instead of cooperation, collaboration dominates. This collaboration was characterised by a common context being created slowly among the public and private members — as manifested by building up a common language and mutual understanding. As in Case 1 the team members of Case 2 kept an open mind in respect to the outcome they had to produce — a report with suggestions for how to improve the processes in a central sterile department. However, Case 2 is different from Case 1 in that the specific nature of the end product was not known in advance. The high degree of collaboration seems to have been needed to support the exchange of knowledge and the creation of a shared knowledge base, thus making it easier for the members to agree on how to produce the end product and what to include within it.

In this case, only a few critical incidents occurred during the innovation process. These were not caused by new information coming from external sources, but instead were related to critical decisions made within the team. These shaped the path of the project and as they were collaboratively determined, the path of the project was never challenged, and the critical incidents therefore were simple and fairly easy to handle. When the first critical incident (1) took place, the team members agreed after some discussion to use operation process management models in their work concerning the flow of surgical instruments in a central sterile department. The foundation of this decision was already grounded in previous meetings where knowledge sharing took place concerning the optimal flow of surgical instruments. This previous knowledge sharing created a common language and a collective understanding of the processes at a central sterile department.

The next critical incident (2) took place when the members had to decide whether to focus on larger central sterile departments in future Danish hospitals, or to focus on decentralised central sterile departments in their final report. However, no disagreements arose as the members decided to include both scenarios (large and decentralised central sterile departments) in the final report. The decision making was fairly smooth because of the previous knowledge sharing process that had taken place during visits to two different central sterile departments in which all team members participated. The two visits promoted the sharing of tacit knowledge and created a *joint experience*. During these visits, public and private members interacted and their heterogeneous knowledge bases were partly integrated. For example, the public members gave the private members a practical demonstration of how central sterile departments function. As a result of this experience the private members could better comment on how the work processes could potentially be optimised using technological solutions.

However at the following meeting attempts at cooperation were less successful. A move to cooperation was precipitated by the private members' frustration with the slowness of a collaborative approach. This resulted in the cooperative distribution of tasks, but only fairly simple ones and the distributed tasks were not solved sufficiently. Therefore the team resumed collaboration again.

At the following meetings the team members organised one-day meetings aimed at writing the report together. As a consequence, the intensity of meetings increased in the final stages of the innovation process and so did the collaborative form of interaction.

4.3. Case 3

Case 3 provides an illustration of how knowledge sharing and creating a knowledge base were neglected mainly due to the dominance of

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cooperative forms of interaction. Case 3 is also characterised by a fairly low degree of opportunities to share knowledge and to achieve a collective understanding of the intended solution because only a few meetings were held by the team. These factors seem to have resulted in an absence of a shared knowledge base between the public and private members. Only few critical incidents took place, and those that did have the potential to develop the project further tended to be ignored or disregarded. The following model displays the innovation process in Case 3.

The beginning of the innovation process was characterised by a disagreement about which team member was going to function as the project leader. The private member, who owned the IT firm that was going to develop the end product (an automatic system for identification of surgical instruments) did not want to function as a project leader because they had not received funding from the project due to their late entrance into the subproject. None of the public members wanted to function as a project leader, as they didn't think that it was their responsibility. Finally, one public member from a central sterile department agreed to act as leader, but only when it was possible without interfering with the public member's ordinary job. The first critical incident (1) was thus handled, but the consequences of the lack of real dedication were substantial. In part probably because this was not discussed and dealt with; instead it tended to be ignored.

Following this incident, the cooperative form of interaction dominated, as the team members did not interact in a common context, and thus failed to establish strong linkages between themselves. Instead they worked separately, and tasks and responsibilities were distributed from the beginning of the project period. The lack of collaborative interaction and the dominance of cooperation meant that only explicit knowledge sharing took place. Explicit knowledge included that the private members' technological knowhow and the public members' knowhow about surgical instruments were exchanged but this occurred without close interaction. For instance at the last of the project meetings, the private firm demonstrated to the public members how the IT system is able to identify surgical instruments. The meeting was only used to demonstrate the state of the technology system and a low degree of knowledge sharing occurred.

At the same meeting a lack of any mutual expectations between the parties became apparent. The private firm expressed their certainty that the hospital where one of the public members worked, would buy the finally developed end product. However, the public member made it clear that the hospital had no intention of buying the developed end product, due to lack of funding. The hospital was only able to contribute by testing the product in their central sterile department. The lack of mutual expectations between public and private members shows that the integration of each other's tacit knowledge did not occur. The episode could have created a critical incident, but the private firm ignored the fact that the hospital had no intention of buying. The private actor seemed to conclude that it was only a matter of developing an excellent product and then the hospital might change their mind. This had the potential for being seen as a critical incident. However, as the private firm did not see the need to make any changes and continued their work in the same way, this meant that no critical incident arose. After this meeting, cooperation continued with the private firm trying to develop the end product alone and without any knowledge sharing with the public members: for instance knowledge about purchasing procedures in hospitals.

The second critical incident (2) took place as technological complications arose for the private firm and it was acknowledged that the end product could not be developed sufficiently for testing during the project period. From this point on, insecurity arose among the team members since the future of the project became uncertain and there were concerns that it might be closed down. This insecurity may have been avoided if the team members across the public and private sectors had had a tacit shared understanding of each other's contexts, which could have been established through the use of the collaborative form of interaction. But the opportunity for engaging more collaborative was neglected. As a result the project eventually stopped in its current form.

4.4. Summing up on Cases 1, 2 and 3

Although the three cases are working on components of the same project, the innovation processes are very different. *Case 1* is characterised by knowledge sharing and building a process that balanced cooperation and collaboration. The case is also characterised by severe critical incidents, which resulted in change in knowledge sharing activities throughout the process. *Case 2* is characterised by a high degree of collaboration and intense knowledge sharing. The team did not distribute tasks to independently complete between meetings to a great degree. Instead they solved tasks together at meetings. Only a few critical incidents occurred and these were concerned with actualising particular tasks. Moreover, the team members were very concerned with maintaining consensus and conformity. *Case 3* is dominated by cooperation and a low degree of knowledge sharing. Further, the case is characterised by conflicts between the public and private members' expectations of each other. However these conflicts were more or less ignored or disregarded. Only explicit knowledge seems to have been shared and no strong linkages or understanding of intentions seem to have been established among the team members — perhaps due to the lack of close interaction.

5. Discussion

The case studies illustrate the impacts of different forms of interaction in heterogeneous teams. Two issues are worth emphasising here.

First, heterogeneity among public and private team members needs to be managed and this includes a need for continually managing how much or how little knowledge to share. In line with the literature, balanced knowledge sharing seems to heighten team performance (Edmondson & Nembhard, 2009; Sapsed et al., 2002). Two points clarify this issue.

First, knowledge sharing and the building of a shared knowledge base are needed to deal with heterogeneity. However, the heterogeneous knowledge bases of the team members should be partially retained. A common shared knowledge base cuts across the private and public team members and facilitates common goals, and this needs to be effectively balanced with different, complementary knowledge bases attached to the tacit knowledge (mental-models) held by the team members. Case 2 is an illustration of too much knowledge sharing dominated by collaborative forms of interaction and too little use of heterogeneous knowledge bases. On the other hand, Case 3 is an illustration of too little knowledge sharing dominated by cooperative forms of interaction, which prevented the development of a common shared knowledge base. Case 1 seems to illustrate a balance in building up a common knowledge base and accepting, at the same time, that different heterogeneous knowledge bases exist. This seemed to happen through time as the team members shared knowledge through a mixed use of collaborative and cooperative forms of interaction.

Second, as shown in Case 1, strong project leadership may assist in overcoming some of the difficulties in shifting between collaboration and cooperation and help in managing how much, or how little, knowledge to share. The project leader in Case 1 took an authoritative position after the critical incidents occurred and shifted the group from teamwork to taskwork. None of the project leaders in the other cases took such an authoritative position in critical situations. This may have caused the team members in Case 2 to be 'stuck' in terms of knowledge sharing activities through continuing with the collaborative form of interaction and neglecting cooperation. As for Case 3, the lack of a leader may have caused the team members to neglect knowledge sharing, which might have helped the members to overcome the challenges

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that arose from having different interpretations of situations and expectations.

The second issue concerns the need to be able to continually re-establish a shared knowledge base, when it has been challenged or disrupted by a critical incident, as this ability seems to secure progress during innovation processes. Two key points also relate to this issue.

First, being able to recreate or re-establish a shared knowledge base is needed, as the shared knowledge base is not a static collective understanding. Rather the common shared knowledge base is exposed to internal or external disturbances and, as such, a collective understanding can increase, decrease or even disappear in response to external events. How a shared knowledge base develops is not only just dependent upon knowledge sharing, but also seems to depend on the nature and timing of critical incidents and the way in which team members handle these critical incidents. Therefore, if the team members succeed in gaining a collective understanding through an established shared knowledge base, it is still necessary to be able to continually recreate or re-establish a collective understanding when critical incidents occur during the innovation processes. In Case 1, the practice of collaboration just after the occurrence of a critical incident seemed to help the team members to readjust or re-establish the shared knowledge base they had thus far achieved. Through a collaborative form of interaction the team adapted a new version of a shared knowledge base. However, following intense collaboration just after a critical incident, a subsequent period of cooperation seemed to prove advantageous for maintaining continuous progress. The predictability which is produced via the cooperative form of interaction, where each team member solves defined tasks separately, seems to create an important common understanding of direction in the innovation process, which also seems to secure progress.

Second, exposing a common shared knowledge base to different types of disturbances also seems to be important for securing progress. The team literature highlights, that being too extreme in knowledge sharing may make it difficult for a team to act on disturbances when they occur (Cooke et al., 2000). Reflecting on disturbances may well be an important process in development of a common knowledge base into a strong collective understanding. Rather, the risk is that a superficial common knowledge base is built, which is not sufficiently resilient to secure progress during innovation processes. Case 3 illustrates this challenge, as critical incidents do take place during the innovation process, but these are handled superficially, or simply ignored. This impedes the teams' ability to make use of external knowledge or views that could have generated a strong shared knowledge base. Instead, Case 3 illustrates that it is difficult for the members to attain a collective understanding of what is happening during the innovation process (Cooke et al., 2000). Misinterpretations arise between a private and public member and as no strong linkages had been established in the team, further knowledge sharing that might result in a common knowledge base became difficult. If critical incidents had occurred, this might have led to stronger linkages and more joint problem solving through the sharing tacit knowledge (Lam, 2000). In Case 1 the critical incidents constituted a fairly high degree of disturbances, which led to change in knowledge sharing activities and changes in the use of both collaborative and cooperative forms of interaction, facilitating both knowledge sharing and further progress in the innovation process over time. Unlike Case 2, the critical incidents in Case 1 were managed not only by dialogue and further knowledge sharing, but also by making decisions that applied the shared knowledge in the team members' individual contexts.

6. Conclusion and implications

The purpose of this article was to achieve a better understanding of how heterogeneous teams share knowledge and secure progress during the innovation process through the use of different forms of interaction i.e. collaboration and cooperation. Three PPI projects from the hospital sector were followed over a period of 1½ years. The use of participant observation and the critical incident method allowed us to examine the unfolding of the innovation process over time in the three cases. The innovation process was particularly challenging for the three PPI teams as the teams consisted of heterogeneous members from the public and private sectors, which contain dissimilar logics, values and mental models. We therefore brought the literatures of teams and group learning into play within the particularly challenging context of Public–Private-Innovation partnerships (PPI).

Combining these streams of literature has enabled us to identify how continual knowledge sharing between public and private team members and the securing of progress during an innovation process can be made through the use of different forms of interaction i.e. cooperation and collaboration. Our findings pinpoint some interesting theoretical implications for the literatures of both team and group learning.

The first theoretical implication arises because our PPI data reveal the importance of being able to continually create a balance between collaborative and cooperative forms of interaction in order to share knowledge and create progress during innovation processes. In the team literature and group learning literature it is widely accepted that sharing knowledge is an obvious requirement, particularly for heterogeneous team members, and that knowledge sharing is created through the use of a collaborative form of interaction. However, our PPI data also reveals the importance of being able to hold different complementary knowledge bases between the heterogeneous team members, as these, when they supplement a common knowledge base, create momentum and progress during innovation processes. As such, to enhance team performance during innovation processes, team members' heterogeneity needs to be dealt with through collaborative interaction, but without completely dissolving the distinction between the heterogeneous knowledge bases of the team members. The cooperative form of interaction form is particularly applicable if heterogeneous team members are to maintain complementary knowledge bases and avoid the dissolution of these within the team. How the forms of interaction, or types of tasks, are combined might also influence the innovation process over time. As one of our cases (Case 1) illustrates, it seems easier to practice taskwork by the use of cooperative interaction if the team members have participated in teamwork beforehand and gained a common understanding of the situation through collaborative interaction and knowledge sharing.

The second theoretical implication concerns the necessity of interrupting the shared knowledge base and being able to re-establish a shared knowledge base over time. Disturbances, if handled correctly, confront the team with some of the insecurities their shared knowledge base is built upon, and make it possible for the team members to further develop a shared knowledge base. As such, our cases illustrate that a balance between forms of interaction does not necessarily secure progress on its own. Disturbances that present new situations and knowledge also seem to be necessary elements for securing progress during innovation processes, as long as these disturbances are handled in a manner that results in re-establishing a new shared knowledge base. Thus, it seems important that a shared knowledge base is challenged over time by critical incidents to secure progress during innovation processes. However, disturbances only secure progress if these are overcome by team members' ability to re-establish and re-negotiate a shared knowledge base, when it has been challenged or disrupted by a critical incident.

6.1. Managerial implications

Three important managerial implications are highlighted here, because they concern challenges to the securing of progress during the innovation process involving heterogeneous team members. First, it is apparent that PPI projects can vary in the degree of

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knowledge sharing and that knowledge sharing can vary across different forms of interaction. As such, it is essential to make use of the two forms of interaction – cooperation and collaboration – strategically because they can be valuable to a project leader in managing an innovation process in PPI projects. The ramping up to collaboration seems to enhance knowledge sharing, whereas the scaling down to cooperation seems to enhance progress, but minimises knowledge sharing.

Second, it might also be necessary to secure and/or support different types of disturbances that may arise in PPI projects. In particular, situations related to critical incidents seem to create reflection and progress among team members. In some situations it might be beneficial to introduce intended disturbances to avoid conformity and to secure progress in the innovation process — for instance, by organising workshops that challenges existing beliefs and logics. In other situations it might be necessary to facilitate close interaction and dialogue among team members in order to stabilise the consequences of unintended disturbances that have taken place. Such situations require more collaboration since there is a need for re-establishment of a shared knowledge base.

The above-mentioned managerial implications suggest a third implication concerning the role of a project manager when dealing with heterogeneous PPI team members. It is important that a project manager is aware that knowledge sharing and integration of both tacit and explicit knowledge possessed by public and private members can be a very fragile process. Sometimes project managers have to facilitate collaboration and interaction among team members and in other situations project managers have to take a more authoritative position. This seems to be relevant especially after critical incidents have taken place. A more authoritative position can help team members when they are 'stuck' in knowledge sharing activities or when team members neglect knowledge sharing.

Balancing collaboration and cooperation in heterogeneous teams is relevant not only in a PPI context but also in wider business settings where heterogeneous teams are used and different team members have to share knowledge. Particularly in settings where firms are increasingly opening up their innovation processes it becomes even more relevant to focus on how heterogeneous teams share knowledge.

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